November 1999 Highlights of the Pulsed Power Inertial Confinement Fusion Program

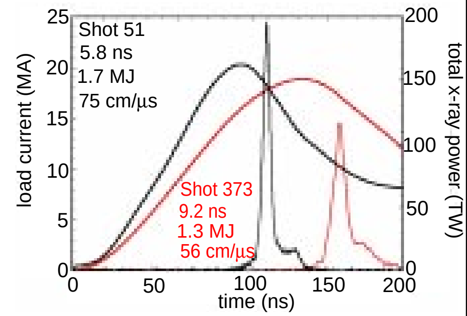

Fig. 1. Current and radiated power for long- and short-pulse Z modes with single array. Power is factor of two lower for long pulse and final pinch diameter is ~50% larger compared to short pulse.

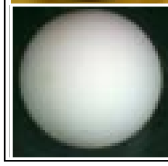

Fig. 2. Foam balls on Shots 371 (upper) and 509 (lower). Shot-371 ball, molded from TPX foam, has prominent seam and large surface defects.

Four z-pinch invited talks were given at the APS Division of Plasma Physics Meeting: two by Sandia, one each by Imperial College and NRL. We had 14 Z shots: 6 dual- and single-pinch shots with a z-pinch-driven hohlraum (ZPDH) to benchmark LASNEX, 2 shots with static-walled, NIF-scale hohlraums, a wire preheating shot, and 5 short circuit shots.

In collaboration with the Defense Threat Reduction Agency, ten Z shots with titanium or molybdenum wire arrays were completed in the previous quarter. Using nested arrays of 4.5 to 6 cm in diameter, 100-cm/µs implosions were achieved with radiated pulses of 5 ns. In parallel with these source physics shots, five samples per shot were fielded to assess radiation effects and develop technologies to improve the testing environment. Candidate neutron generator materials were tested with a record Ti K-shell (4.8-keV) yield of 137 kJ, and reentry-vehicle heat shield materials were tested with Ti and Mo sources at fluence levels and photon energies previously possible only underground. We also demonstrated lithium debris-slowing shields and the closure of 3.8- and 10.2-cm explosively-driven valves in 200 µs.

In 1998 we delivered nearly twice the energy to the Saturn vacuum section by shorting the water output switches so the current rise time to the load increased from 50 to 230 ns (May 1998 *Highlights*). A comparable rise time and radiated power for a lower implosion velocity suggested reduced costs and power flow risks for future accelerators. We are assessing a long-pulse mode on Z and have delivered 27 MA in a 170-ns implosion pulse (long compared to 100 ns in a short-pulse mode). Preliminary data on Z give a lower peak radiated power and longer pulse rise time compared to x-ray pulses in the short-pulse mode (Fig. 1). 2-D radiation magnetohydrodynamic simulations indicate the lower radiated powers on Z are a consequence of a lower implosion velocity. These computer simulations and the heuristic modeling of Imperial College indicate that, on the lower-current Saturn, a different mechanism--the merger of individual wire plasmas prior to acceleration of the plasma shell--dominates the long-pulse implosion physics. We can partially offset the effect of the lower velocity on Z by using a nested wire array. Such a configuration increases the x-ray power from ~100 TW to 145 TW. To further increase the power, nested arrays at larger diameters would be necessary.

The 1-2% radiation flux uniformity for high-convergence capsule implosions requires a two-sided drive for the ZPDH concept. 3-D view factor modeling indicates that the asymmetry can be reduced to 2-4% at radiation temperatures attainable on Z for two perfectly timed pinches. The imbalance in power and timing of a dual pinch, however, can affect the polar illumination symmetry, and the quality of the diagnostic foam ball can affect our measurement accuracy on Z. The hardware to evaluate the flux uniformity is being improved. The foam balls are now diamond-turned by General Atomics from polystyrene raw stock and are close to perfect spheres with no seams and a minimum of surface defects (Fig. 2). Moreover, we have a new design for the dual-pinch hardware with two independently loadable wire arrays that can meet the near-term requirements for symmetry experiments on Z.

Contact: Keith Matzen, Inertial Confinement Fusion Program, Dept. 1670, 505-845-7756, fax: 505-845-7464, email: mkmatze@sandia.gov
Highlights are prepared by Mary Ann Sweeney, Dept. 1670, 505-845-7307, fax: 505-845-7464, email: masween@sandia.gov.
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